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PROGRAM AND ABSTRACTS OF PAPERS CITRUS RESEARCH CONFERENCE

December 4, 1962

Fruit and Vegetable Chemistry Laboratory
263 South Chester Avenue
Pasadena, California

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Fruit and Vegetable Chemistry Laboratory
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Western Utilization Research and Development Division
Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

FOREWORD

This Citrus Research Conference is being held to bring to members of the citrus and allied industries in Southern California and Arizona the latest results of research on the chemistry, pharmacology, and technology of citrus fruits and their products carried on by laboratories of Utilization Research and Development, Agricultural Research Service, U. S. Department of Agriculture. The following Divisions are participating in this year's conference.

Western Utilization Research and Development Division:
Western Regional Research Laboratory (Division
headquarters), 800 Buchanan Street, Albany 10,
California

Fruit and Vegetable Chemistry Laboratory, 263
Chester Avenue, Pasadena, California

Southern Utilization Research and Development Division:
U. S. Fruit and Vegetable Products Laboratory,
600 Avenue S, N.W., Winter Haven, Florida

U. S. Fruit and Vegetable Products Laboratory,
509 West Fourth Street, Weslaco, Texas

P R O G R A M
C I T R U S R E S E A R C H C O N F E R E N C E
Tuesday, December 4, 1962

9:30 a.m.

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M. J. Copley, Director, Western Utilization Research and
Development Division, Albany, California - Presiding

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Laboratory, Pasadena, California - Presiding

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PRESENT STATUS OF FOAM-MAT DRYING

A. I. Morgan, Jr.

Western Utilization Research and Development Division
Western Regional Research Laboratory
Albany, California

Foam-mat drying produces good instant powders from liquid foods cheaply. It consists of air-drying thin pieces of stiff foams made from the food or food concentrate. An edible foam stabilizer is often used with the food to insure that the foam does not collapse early in the drying operation.

Continuous commercial-scale foam-mat drying equipment is now being offered for sale by three U. S. manufacturers. Two large production dryers have been installed, one mainly for tomato paste and one for baby foods. A third large unit is available for testing. Six continuous automatic pilot plants are in use in this country. Several pilot dryers without automated feeding and collecting have also been completed. Development of citrus powders by foam-mat drying is under way in a pilot plant in Europe.

Several methods of spreading the foam thinly for drying are in use. In one case, the foam is laid on a belt which carries it through warm air streams flowing across the food while heat is applied to the bottom of the belt. The foam can be a thin layer covering the belt or a number of thin extrusions lying near each other. A somewhat thicker layer, however, can be laid on perforated trays. The foam layer can be pierced by air jets and the trays stacked in a through-flowing column of warm air. Both types of equipment are being offered commercially.

Orange powder has been produced by both variations during the last year in our laboratories. When properly operated, juice quality by each method is high. Much higher production can be achieved with through-flow (crater) for a dryer of a given cubic volume. If quality can be maintained, however, very thin layers can be dried on a belt in 1 to 3 minutes, resulting in still higher production rates. The tray concept is probably limited to 200 lbs. of powder per hour per unit, whereas the belt may be as long as desired.

The color and density of the orange powder have been improved by flaking the pieces of dry foam between warm rolls. This considerably improved reconstitution in ice water.

Finish drying of orange powder is still under scrutiny. Unfortunately, extractive drying by alcohol is not possible for orange powders. Only methanol is adequately effective as a substitute for in-package desiccation, and removal of traces of the alcohol is difficult.

A number of companies have cooperated with the Albany laboratory in the application of foam-mat drying to their own commodities. This program continues, together with work on the flavor concentration and restoration.

RECENT DEVELOPMENTS IN THE CHEMISTRY OF FLAVONOID GLYCOSIDES

R. M. Horowitz and Bruno Gentili

Western Utilization Research and Development Division
Fruit and Vegetable Chemistry Laboratory
Pasadena, California

Further information has accumulated on the nature of the sugar constituents in the flavonoid glycosides of citrus fruits. Ozonolysis of the appropriate glycosides has yielded the isomeric disaccharides, neohesperidose (2-O- α -L-rhamnosyl-D-glucose) and rutinose (6-O- α -L-rhamnosyl-D-glucose). Neohesperidose is the disaccharide in the bitter flavanones naringin, neohesperidin, and poncirin. Neither disaccharide was obtained crystalline but each yielded a crystalline acetyl derivative. Reduction of the disaccharides with sodium borohydride yielded the corresponding "itols", neither of which crystallized.

It has been found possible to separate neohesperidose and rutinose from each other and from various other sugars by paper electrophoresis in sodium borate solution. Similarly, neohesperiditol and rutinitol can be conveniently separated by this procedure. The relative rates of migration of these compounds in the electric field are in accord with the assigned structures. It also appears possible to separate corresponding pairs of glycosides that contain neohesperidose or rutinose by paper electrophoresis. Optical rotational data show clearly that the rhamnose in both neohesperidose and rutinose has the alpha configuration. The structure of neohesperidose reported recently by Nakabayashi will be discussed and it will be pointed out that his results are in sharp conflict with our own. Relations between the taste and structure of various glycosides containing neohesperidose and rutinose will be discussed.

A 4'-glycoside of vitexin has been isolated from oranges and its hydrolytic products have been tentatively identified. Vitexin is a flavone of the apigenin series and contains a carbon-linked sugar residue in the 8-position. A brief review will be given of the present information on the occurrence of vitexin and vitexin analogs in citrus and other species will be reviewed briefly.

STUDIES ON THE PHARMACOLOGY OF PECTIN AND FLAVONOID DERIVATIVES

Floyd DeEds

Western Utilization Research and Development Division
Western Regional Research Laboratory
Albany, California

Caloric availability assays on pectin by the procedure of Rice et al. (J. Nutrition, 61, 253, 1957) showed that the small amount of pectin digested by rats was not well utilized as an energy source for growth. Most of the pectin fed to the rats was accounted for by increase in fecal weight. The excretion of undigested pectin may play a role in the reported ability of pectin to lower blood and liver cholesterol levels induced by dietary cholesterol.

The acute toxicity and metabolism of the dihydrochalcone derivatives of naringin and neohesperidin have been studied. Oral doses of these derivatives given twice daily to mice for three successive days totaled 6000 mg. per kilo of body weight. No evidence of toxicity was noted. No deaths resulted from the intraperitoneal injection in mice of the dihydrochalcone of naringin in doses as high as 1000 mg. per kilo of body weight. The intraperitoneal injection of the dihydrochalcone of neohesperidin proved fatal in doses between 800 and 1000 mg. per kilo of body weight.

The metabolites of the dihydrochalcone of naringin were the same as those of naringenin, namely, p-hydroxyphenylpropionic acid, p-coumaric acid, and p-hydroxybenzoic acid and its ethereal sulfate. The dihydrochalcone of neohesperidin was metabolized to yield a small amount of m-hydroxyphenylpropionic acid, the principal metabolites being iso-ferulic acid, dihydroferulic acid, and isovanillic acid and its glycine conjugate.

SOME ASPECTS OF THE CHEMISTRY OF THE BITTER PRINCIPLES
OF NAVEL ORANGE JUICE

David L. Dreyer, Jr.

Western Utilization Research and Development Division
Fruit and Vegetable Chemistry Laboratory
Pasadena, California

Navel oranges grown in California are seldom used for processing because the extracted juice becomes bitter and unpalatable when heated or exposed to air for even a few hours. Intensity of the bitterness is largely dependent upon the maturity of the fruit, being most pronounced in juices from early season fruit and varying from season to season. The long standing problem of navel juice bitterness will be reviewed and the chemical aspects discussed. The known compounds responsible for navel bitterness will be described and particularly the unique reactions of limonin, the major bitter constituent, which hold some promise of being used in the development of a practical process for debittering the juice. For example, limonin may be converted by air oxidation with a sensitizer to give the nonbitter limonexic acid.

Commercial enzymes have been tested in bitter navel juice as one approach to a solution of the debittering problem. Extensive cloud loss occurs with many of the enzyme preparations tested to date and any decrease in bitterness of the juice appears to parallel the degree of cloud loss. This raises the question, first suggested by McColloch of this laboratory, that the enzyme preparation may cause a breakdown of the colloidal state of the system, resulting in a shift of limonin from the colloidal phase to the insoluble-solids phase to bring about a decrease in bitterness. In this case, debittering might well be a physical instead of a chemical mechanism.

The biosynthesis from euphol and the botanical distribution in nature of the triterpenoid bitter materials (nimbin, swietenolide, gedunin, cedrelone, khivorin, swietenin, limonin, obacunone, and nomilin) will be outlined.

CARBONYL AND TERPENE ANALYSIS OF COLD-PRESSED ORANGE OIL

G. L. K. Hunter, W. B. Brogden, Jr., and Genet L. Parks

Southern Utilization Research and Development Division
U. S. Fruit and Vegetable Products Laboratory
Winter Haven, Florida

In order to study the effects of various processing parameters on orange product flavor it was necessary to elucidate the chemical composition of cold-pressed orange oil. Established reported procedures were used for the separation of terpenes from the terpenoids present in the whole oil. Cold-pressed orange oil was treated with silica gel and the terpene fraction was eluted with hexane, stripped of solvent, and rectified. The fractions appearing before and following d-limonene were further separated by gas chromatography to reveal the presence of 15 terpenes. The individual peaks were collected from a preparative-scale gas chromatograph and analyzed by infrared spectroscopy. Twelve constituents were identified as alpha-thujene, alpha-pinene, camphene, sabinene, myrcene, delta-3-carene, alpha-phellandrene, alpha-terpinene, d-limonene, gamma-terpinene, p-cymene and terpinolene. Infrared spectra have been obtained on the remaining three terpenes and these are in the process of structural elucidation.

During this work it was observed that isomerization and disproportionation took place on large silica gel columns while deterpenating substantial quantities of oil. It was observed that under these conditions d-limonene isomerized to alpha-terpinene, gamma-terpinene, p-cymene, and terpinolene. Under more vigorous conditions 1-p-menthene, t-2-p-menthene, 3-p-menthene, t-8(9)-p-menthene and p-cymene were formed. It was also observed that p-cymene dimerized to 1,3,3,6-tetramethyl-1-p-tolyindane. Each p-menthadiene found in the oil was treated with silica gel to give the same products as d-limonene, including dipentene. Since these p-menthadienes isomerized to give only those found in the original oil, d-limonene could be the major precursor to these particular p-menthadienes in the oil.

Myrcene, a terpene constituent of orange oil, also underwent isomerization on silica gel to give the compounds described above and in addition gave ocimene and alpha-phellandrene.

The bicyclic terpenes found in the orange oil were isomerized on silica gel at elevated temperatures. Alpha-pinene yielded camphene, alpha-terpinene, dipentene, gamma-terpinene, terpinolene and isoterpinolene. These disproportionated to give the products described above. Camphene isomerized to tricyclene. The data show that sabinene isomerized to alpha-thujene, which gave the products observed for alpha-pinene except camphene and in addition alpha and beta-phellandrene. Delta-3-carene isomerized to delta-4-carene, alpha and gamma-terpinene, isoterpinolene and m-menthadienes. These, too, disproportionated to p-menthenes, p-cymene, and m-cymene.

These results indicate that d-limonene could be the precursor to the p-menthadienes found in orange oil. Camphene in the oil also appears to be an

acid-catalyzed isomerization product from alpha-pinene, and the presence of alpha-phellandrene could be traced to the acid-catalyzed cyclization of myrcene which is assumed to be a product of dehydration under these conditions. It is hoped that the precursors to all of the orange oil constituents can be elucidated in this way, thus providing an understanding into the changes in flavor.

The effects of carbonyl constituents on flavor are recognizably important. It was desirable to isolate and identify these constituents without rearrangement or artifact formation. Cold-pressed orange oil was treated with silica gel and the terpenes removed with n-hexane according to established procedures. The adsorbed terpenoids were then removed with isopropanol. The residue following removal of the solvent was treated with Girard-T reagent and the carbonyls, isolated as salts, were regenerated with formaldehyde. During this work it was observed that artifacts were introduced into the system traceable to impurities in the formalin solution; however, extraction of the formalin solution prior to use with isopentane removed the extraneous materials. The use of isopropanol or tert-butanol for the extraction of the regenerated carbonyls precluded the formation of acetals.

The regenerated carbonyls were further separated by gas chromatography and the material from the individual peaks analyzed by infrared spectroscopy. The analysis showed the presence of n-octanal, n-nonanal, citronellal, n-decanal, n-undecanal, neral, geranial, n-dodecanal, and carvone. Alpha-terpineol continually appeared as a contaminant. These compounds have been previously reported by other investigators.

It was observed that the citronellal concentration decreased noticeably when large silica gel columns were used during the initial deterpination step. It has subsequently been shown that citronellal readily isomerized to isopulegol by cyclization on silica gel. Isopulegol had been found in the analysis products whenever the citronellal concentration was low. It was further observed that preparatory gas chromatographic columns containing Carbowax 20M also isomerized citronellal to isopulegol; however, capillary columns containing this substrate did not promote this isomerization. Isopulegol was found to be quite stable and did not undergo further isomerization or give dehydrated products under these mild conditions.

It is entirely feasible to utilize the established procedures discussed above for the analysis of carbonyls, provided precautions are taken to prevent the formation of artifacts. Silica gel free of alumina at low temperatures will not readily promote isomerization. Analysis of these carbonyls should be carried out on capillary columns which have been found to reduce and in most cases eliminate artifact formation.

VOLATILES FROM ORANGES

Roy Teranishi

Western Utilization Research and Development Division
Western Regional Research Laboratory
Albany, California

A systematic investigation of volatiles from condensate and cold-pressed oils from oranges has been started in our laboratory. Fractions isolated are added to reconstituted juice from puff-dried (vacuum) powder to determine desirability organoleptically. Purity or complexity of the fractions is analyzed by gas chromatography, and structure determination of pure fractions is done with the help of nuclear magnetic resonance, infrared, and mass spectra.

Investigation of the lower boiling fraction has been partially completed. The following hydrocarbons have been found: limonene, myrcene, alpha-pinene, alpha-thujene, camphene, alpha-phellandrene, alpha-terpinene, gamma-terpinene, p-cymene, and 4,alpha-dimethylstyrene.

Investigation of the higher boiling material has just been started, and five different sesquiterpenes have been isolated. The major sesquiterpene in the cold-pressed oil was found to be beta-bisabolene, but the major sesquiterpene found in the condensate oil has not yet been related to any known compound. Of those present in lesser amounts, one has been tentatively identified as farnesene.

SESQUITERPENE HYDROCARBONS OF LEMON OIL

Wm. MacLeod, Jr., and Larry Rolle

Western Utilization Research and Development Division
Fruit and Vegetable Chemistry Laboratory
Pasadena, California

Examination of cold-pressed California lemon oil revealed the presence of at least eight different sesquiterpenes. Whole lemon oil was passed through silicic acid columns to remove the oxygenated compounds. The hydrocarbon fraction obtained consists largely of terpenes which are hydrocarbon compounds containing ten carbon atoms in the molecule. Terpenes may also be thought of as condensation products of two five-carbon isoprene units. Sesquiterpenes are related to terpenes in that they may be considered as condensation products of three isoprene units. Since sesquiterpenes contain fifteen carbon atoms per molecule they are readily separated from the lower-boiling terpenes by fractional distillation or gas chromatography. Of the eight sesquiterpenes shown to be present in lemon oil the two major ones were shown by preparative gas chromatography and infrared and nuclear magnetic resonance spectroscopy to be β -bisabolene and bergamotene.

STUDIES ON THE CAROTENOIDS OF LEMON JUICE

Henry Yokoyama

Western Utilization Research and Development Division
Fruit and Vegetable Chemistry Laboratory
Pasadena, California

The carotenoids of the more intensely colored citrus fruits have been the subject of many investigations. Early work by Natarajan and McKinney at the University of California showed that the pigments in Valencia orange juice were complex mixtures of carotenoids, mainly xanthophyll esters with small amounts of carotenes. Curl at the Western Regional Research Laboratory made a comprehensive study of the carotenoids of tangerines, California Valencia orange, Ruby Red grapefruit and Meyer lemons. No detailed work has been reported on the carotenoids in the less pigmented varieties of lemons.

Preliminary studies have been underway to examine the carotenoids present in extracts of fresh lemon juice made from commercial varieties of fruit grown in California. Using several different adsorbents, the saponified carotenoids were separated by column chromatography into fourteen individual carotenes and xanthophylls, two of which appear to be new compounds. The remaining five components were found to be stereoisomers. The major components in lemon juice were found to be phytofluene, zeta-carotene and cryptoxanthin. Several of the minor constituents were tentatively identified. Although phytofluene was found in the juice, phytoene could not be detected even at trace levels. Physicochemical evidence for the structures of these compounds will be discussed and their distribution patterns described.

USE OF DEBITTERED GRAPEFRUIT JUICE AS A BASE FOR
FRUIT AND BERRY FLAVORED PUNCHES AND DRINKS

B. J. Lime, F. P. Griffiths, and D. M. Tucker

Southern Utilization Research and Development Division
U. S. Fruit and Vegetable Products Laboratory
Weslaco, Texas

The enzymatic debittering of grapefruit juice increased its flavor compatibility with such flavors as strawberry and raspberry. Debittering made it possible to increase the quantity of grapefruit juice in the juice blends and drink bases. Highly acceptable drinks were prepared with partially and completely debittered grapefruit juice blended with juice or puree from such fruits and berries as orange, strawberry, raspberry, blackberry, and plum.

A series of orange-strawberry flavored grapefruit drinks was prepared by use of debittered grapefruit juice, partially debittered grapefruit juice, and normal grapefruit juice. Another series was prepared from partially debittered grapefruit juice with sugar contents of 10, 13, and 16 percent and a constant acid content, and with acid contents of 0.50, 0.70, and 0.90 percent and a constant sugar content. These juices were used in determining the preference of two taste panels for levels of bitterness, acid, and sugar. One panel was composed of 51 adults and the other, of 25 seven-year-old children. Eighty-six percent of the adults tested preferred no or medium bitterness, while 68 percent of the children preferred no or medium bitterness. Twenty percent of the adult panel and 32 percent of the children's panel preferred the low acid drink, while 39 percent of the adults and 28 percent of the children preferred the middle acid drink. Sixty percent of the children and 35 percent of the adults indicated a preference for the high sugar drink, and 20 percent of the children and 49 percent of the adults preferred the middle sugar level drink. While 25 percent more of the children preferred the sweeter drink, the adults and children showed the same preference for the higher acid drink.

A triangle taste panel composed of 14 adult members was used to examine the effect of pH upon the taste perception of sweet and sour flavor of partially debittered grapefruit based drinks. With the sugar level constant, the panel could detect a difference of 0.15 percent acid, which was statistically significant. With the acid level constant, a difference of 1.5 percent sugar was significant. When the acid and sugar levels were constant, a change of 0.2 in pH could be detected on a significant level. A difference of 0.2 percent acid could be compensated for by increasing the pH of the high acid drink to 0.3 more than the pH of the low acid drink, as indicated by the taste panel when it failed to detect a difference on a significant level between the two drinks.

LIST OF CITRUS PUBLICATIONS
AND PATENTS*

September 1, 1961 to October 31, 1962

Western Utilization Research and Development Division
Fruit and Vegetable Chemistry Laboratory
263 South Chester Avenue, Pasadena, California

A TEST FOR CHALCONES IN LEMON OIL

W. L. Stanley

J. Assoc. Off. Agr. Chem. 44(3): 546-548, 1961

DETERIORATION OF LEMON OIL. FORMATION OF p-CYMENE FROM γ -TERPINENE

R. M. Ikeda, W. L. Stanley, S. H. Vannier, and L. A. Rolle

Food Technol. 15(9): 379-380, Sept. 1961

HYDROCARBON COMPOSITION OF LEMON OILS AND THEIR RELATIONSHIP TO OPTICAL ROTATION

W. L. Stanley, R. M. Ikeda and S. Cook

Food Technol. 15(9): 381-385, Sept. 1961

DETERMINATION OF CITRAL IN CITRUS EXTRACTS AND CITRUS OILS BY CONVENTIONAL AND MODERN CHEMICAL METHODS OF ANALYSIS

F. Yokoyama, L. Levi, P. M. Laughton, and W. L. Stanley

J. Assoc. Off. Agr. Chem. 44(3): 535-541, Aug. 1961

STUDIES ON THE STRUCTURE AND BITTERNESS OF THE FLAVONOID GLYCOSIDES OF CITRUS

R. M. Horowitz

Proceedings of Symposium on Biochem. of Plant Phenolics Substances, Colo. State Univ., Ft. Collins, Aug. 31-Sept. 1, 1961, pp. 1-8, Aug. 1962.

LEMON OIL COMPOSITION. ISOLATION AND IDENTIFICATION OF ALDEHYDES IN COLD-PRESSED LEMON OIL.

R. M. Ikeda, L. A. Rolle, S. H. Vannier, and W. L. Stanley

J. Agr. and Food Chem. 10(2): 98-102, March-April 1962

MONOTERPENE HYDROCARBON COMPOSITION OF SOME ESSENTIAL OILS

R. M. Ikeda, W. L. Stanley, S. H. Vannier, and E. M. Spitler

J. Food Sci. 27(4) Sept.-Oct. 1962

* Reprints are available at the addresses indicated; patents are available only by purchase at 25¢ a copy from the U. S. Patent Office, Washington D. C.

Western Utilization Research and Development Division
Western Regional Research Laboratory
800 Buchanan Street, Albany 10, California

THE CAROTENOIDS OF NAVEL ORANGES

A. Laurence Curl and Glen F. Bailey
J. Food Sci. 26(4): 422-427, July-Aug. 1961

THE REVERSIBLE NEPHROTOXIC EFFECTS OF BIPHENYL

Albert N. Booth, Anthony M. Ambrose, Floyd DeEds, and Alvin J. Cox, Jr.
Toxicol. and Appl. Pharmacol. 3(5): 560-567, Sept. 1961

CAROTENOID EPOXIDE DETECTION. AN IMPROVED TEST FOR CAROTENOID EPOXIDES

A. Laurence Curl and Glen F. Bailey
J. Agr. and Food Chem. 9(5): 403-405, Sept.-Oct. 1961

ALIGNMENT CHART SPEEDS COMPUTATIONS OF QUALITY CHANGES IN FROZEN FOODS

W. B. Van Arsdel
Food Proc. 22(12): 40-43, 45, Dec. 1961

DETERIORATION IN STORAGE

A. Laurence Curl and William F. Talburt
In Fruit and Vegetable Juice Processing Technology, Chap. 14, pp. 410-446,
Westport, Conn., 1961

SELECTIVE ALKYLATION OF POLYPHENOLS. I. THE USE OF DIPHENYLMETHYLENE AS A PROTECTIVE GROUPING FOR O-DIHYDROXYFLAVONES

Leonard Jurd
J. Org. Chem. 27: 872-875, March 1962

ENZYMIC METHYLATION OF SOME PHENOLIC ACID SUBSTRATES OF POLYPHENOLOXIDASE (abstract)

B. J. Finkle and R. F. Nelson
Fed. Amer. Soc. Expt. Biol. Proc. 21(2): 228, March-April 1962

THE CAROTENOIDS OF MEYER LEMONS

A. Laurence Curl
J. Food Sci. 27(2): 171-176, March-April 1962

SELECTIVE ALKYLATION OF POLYPHENOLS. II. METHYLATION OF 7,4' AND 3' HYDROXYL GROUPS IN FLAVONOLS

Leonard Jurd
J. Org. Chem. 27: 1294-1297, April 1962

GAS CHROMATOGRAPHY. DIRECT VAPOR ANALYSES OF FOOD PRODUCTS WITH PROGRAMMED TEMPERATURE CONTROL OF DUAL COLUMNS WITH DUAL FLAME IONIZATION DETECTORS

Roy Teranishi, Ron G. Buttery, and Robert E. Lundin
Anal. Chem. 34: 1033-1034, July 1962

HOW FOAM-MAT DRYER IS MADE

W. C. Rockwell, E. Lowe, A. I. Morgan, Jr., R. P. Graham, and L.F.Ginnette
Food Engin. 34(8): 86-88, Aug. 1962

THE METABOLIC FATE OF PHENOLIC SUBSTANCES IN ANIMALS

A. N. Booth

Symposium on Biochemistry of Plant Phenolic Substances Proceedings,
Aug. 31 to Sept. 1, 1961, Colorado State University, Fort Collins,
pp. 72-97, Aug. 1962

SPECTRAL PROPERTIES OF FLAVONOID COMPOUNDS

Leonard Jurd

In The Chemistry of Flavonoid Compounds, T. A. Geissman, ed., pp. 107-
155, Pergamon Press, New York, 1962

Southern Utilization Research and Development Division
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THE DETERMINATION OF SOLUBLE SOLIDS IN CITRUS JUICES. III. EMPIRICAL FACTORS FOR CONVERTING REFRACTOMETER AND DENSITY VALUES TO SOLUBLE SOLIDS

W. C. Scott and M. K. Veldhuis

Food Technol. 15(9): 388-391, Sept. 1961

EQUILIBRIUM MOISTURE CONTENT OF ORANGE JUICE POWDERS AT LOW RELATIVE HUMIDITIES

C. J. Wagner, Jr.

Proc. Florida State Hort. Soc. 74: 287-291, 1961

ESTIMATION OF COLUMN HOLD-UP TIME IN GAS CHROMATOGRAPHY USING IONIZATION DETECTORS

H. J. Gold

Anal. Chem. 34: 174, 1962

EFFECT OF PRESERVATIVES AND STORAGE TEMPERATURES ON SHELF LIFE OF CHILLED CITRUS SALADS

N. B. Rushing and V. J. Senn

Food Technol. 16(2): 77-79, Feb. 1962

NATURE OF EXTRANEEOUS PEAKS IN THE GAS CHROMATOGRAPHIC ANALYSIS OF GIRARD-T ISOLATED CARBONYLS

G. L. K. Hunter and R. F. Struck

Anal. Chem. 34: 864-865, 1962

ORANGE AND TANGERINE JUICES

M. K. Veldhuis

In Fruit and Vegetable Juice Processing Technology, Chap. 25, pp. 838-
873, Westport, Conn., 1961

Southern Utilization Research and Development Division
U. S. Fruit and Vegetable Products Laboratory
509 W. 4th Street, Weslaco, Texas

BIOSYNTHESIS OF STIGMASTEROL IN TOMATO FRUITS

R. D. Bennett, E. Heftmann, A. E. Purcell, and J. Bonner
Science 134 (3480): 671-672, Sept. 8, 1961

SEASONAL VARIATION OF TEXAS VALENCIA ORANGE JUICE

B. J. Lime and D. M. Tucker
J. Rio Grande Valley Hort. Soc. 15: 29-31, 1961

OBSERVATIONS ON THE COLOR OF RED GRAPEFRUIT SEEDLINGS

A. E. Purcell and R. Hensz
J. Rio Grande Valley Hort. Soc. 15: 78-79, 1961

PARTY PUNCH. HOME PREPARATION OF CITRUS DRINK CONCENTRATES

B. J. Lime and F. P. Griffiths
Texas Farming and Citriculture 38(8): 26-B, 1962

PRODUCTION OF PULP FORTIFIED CONCENTRATE FROM RUBY RED GRAPEFRUIT - A PROGRESS REPORT

D. M. Tucker and B. J. Lime
J. Rio Grande Valley Hort. Soc. 16: 112-120, 1962

SEASONAL VARIATION IN TEXAS HAMLIN AND MARRS ORANGE JUICE 1961-1962

B. J. Lime and D. M. Tucker
J. Rio Grande Valley Hort. Soc. 16: 78-82, 1962

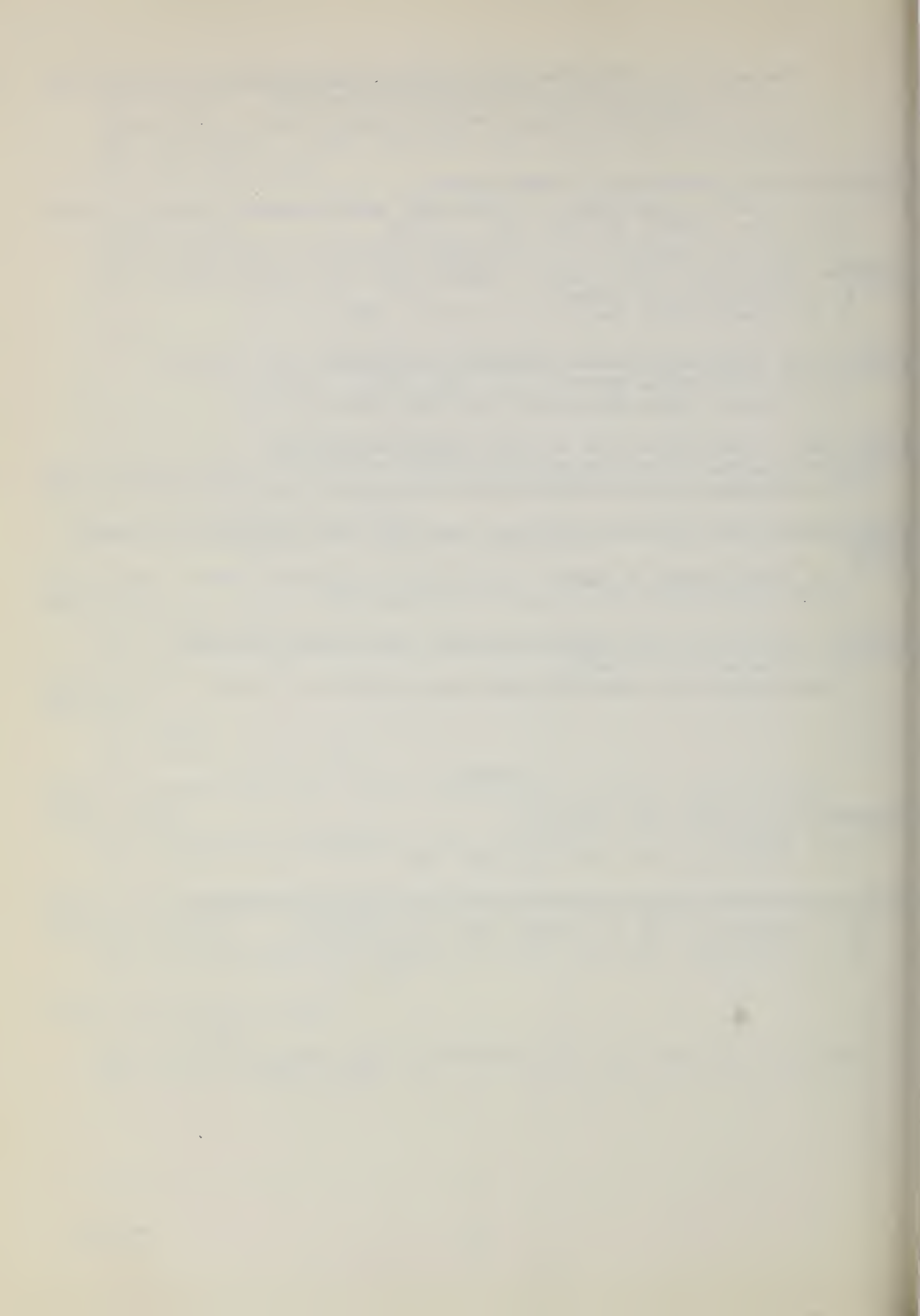
PATENTS

*DEHYDRATION OF FRUITS AND VEGETABLES

A. I. Morgan, Jr., L. F. Ginnette, and R. P. Graham
U. S. Patent No. 3,031,313, April 24, 1962

*PROCESS FOR REMOVAL OF RESIDUAL MOISTURE FROM DEHYDRATED PRODUCTS

A. I. Morgan, Jr., R. P. Graham, and L. F. Ginnette
U. S. Patent No. 3,031,312, April 24, 1962





Growth Through Agricultural Progress